OCR
RECOGNISING ACHIEVEMENT

GCE ADVANCED UNIT

G628/INSERT

APPLIED SCIENCE

Unit 9: Sampling, testing and processing

INSERT

THURSDAY 7 JUNE 2007

Afternoon

Time: 1 hour 30 minutes

CUP/T28030

INSTRUCTIONS TO CANDIDATES

- Questions 1 and 2 are based on the articles which follow on pages 2–5 of this Insert.

This document consists of **6** printed pages and **2** blank pages.

The manufacture and uses of cement products

Cement has been used in the construction industry since 1750 and, with some modifications, the same method has been used for its manufacture up to the present day. The normal type of cement used is Portland cement, probably because it was originally manufactured from limestone obtained from Portland in Dorset but the name Portland has gradually lost usage.

The raw materials used are chalk (or limestone) and clay. A method of manufacturing cement is shown in Fig.1.1.

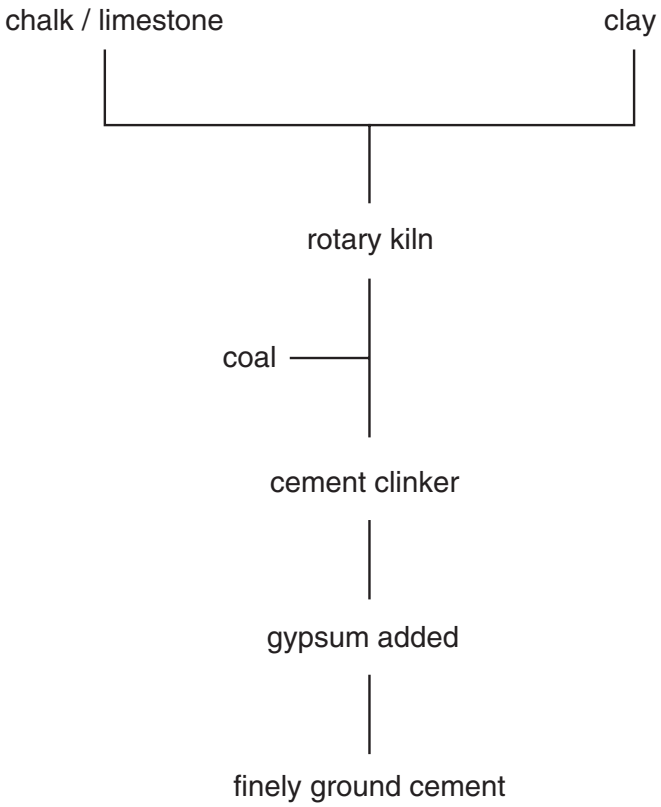

Fig. 1.1

After mixing the limestone and clay, a fuel is used (traditionally coal) to gradually raise the temperature in the kiln to 1500 ^{o}C. At this temperature chemical reactions cause the mixture to fuse together, which, on cooling, gives small balls of solid cement clinker. A small amount of gypsum is then added to the cooled clinker and the mixture finely ground and mixed.

Chemically, cement is largely a mixture of calcium silicate and calcium aluminate. When water is added a paste forms which then slowly hardens. The rate of setting is of vital importance.

Regular testing of cement is necessary during its manufacture to check its uniformity and consistency. The chemical testing of cement includes quantitative analysis for elements such as calcium, magnesium, potassium, sodium and silicon. Analysis for calcium is carried out by flame emission spectroscopy (FES). The cement is also tested for the fineness of the powder and its setting time when mixed with water.

Considerable heat is needed when cement is manufactured. The burning of fossil fuels is used to generate the heat but this also forms carbon dioxide gas. This gas is also produced during the manufacturing process as limestone decomposes.

It is important to try and reduce the use of fossil fuels and the production of carbon dioxide that this method of cement production involves. Attempts are being made to use other materials to reduce the amount of cement being made. These should be 'ecofriendly' but must have cement-like properties.

When iron oxide is reduced to iron in a Blast Furnace considerable quantities of carbon dioxide are given off and a slag is formed from impurities. This slag, mainly calcium silicate, is ground up to produce GGBS (ground granulated blast furnace slag) and this has been used as a partial replacement for cement in the production of concrete. The manufacturers of GGBS comment that no quarrying is required for its manufacture and that no carbon dioxide is produced in the process.

A more recent advance is in the development of geopolymer cements. One type of geopolymer cement is simply made by taking clay and treating it for a short period of time with a very concentrated solution of the alkaline substance sodium hydroxide at 150 ^{o}C and at a pressure of 50 atmospheres. The resulting material is a polymer with bonds containing the grouping

$$\text{Si} - \text{O} - \text{Al} - \text{O}$$

These materials have cement-like properties and have important developing uses in the construction industry.

Research is also taking place into the production and uses of magnesium phosphate-based cements.

Traditionally Portland cement has been used for many years and has wide uses. However, its manufacture is costly in terms of the energy needed. These newer products are proving to be effective additions to the cement range of materials and their outlook is promising.

[Turn over

Bamboo – an essential plant for life

Bamboo is an important resource for many people around the world. It has many applications, which include uses as a construction material, in medicine, as a food, in papermaking and as the basis of a number of traditional musical instruments.

The plant, a member of the grass family, grows best in tropical countries but some varieties can be found in mountainous areas in temperate zones. Bamboo is one of the fastest growing plants on earth. Some varieties can grow as much as one metre in a day. The plants can be as short as 30 cm high or, for giant varieties, grow to 35 m tall.

There are two main types of bamboo. One type spreads by underground rhizomes and this can double in size in a year, Fig. 2.1. The other type grows in clumps and spreads more slowly, Fig. 2.2.

2 photos have been removed due to third party copyright restrictions

Details:

Photos of 2 different types of bamboo

Fig. 2.1

Fig. 2.2

One advantage of bamboo, compared to other plants, is that it is very resistant to insects and diseases. A reason for this may be that the outside of these stems (the culms), are very hard and impervious to water. The outside of these stems can contain up to 7% of silica (SiO_2).

However, the bamboo is sometimes attacked by mites. Mites are related biologically to spiders. Mites which attack bamboo are very small, typically only 0.5 mm in size. They cause damage by sucking sap from the leaves. Eradication of these mites is difficult, partly because of their small size.

Methods of eradication of the mites include

- Cutting down the bamboo and burning the debris but this leads to loss of the plantation.

- Spraying infected plants with a contact insecticide can be used but a systemic insecticide is more effective. Even this does not kill the eggs and spraying at the correct time in the life cycle of the mite is obviously important.

- Another method is to use predator mites that attack the sap-sucking mites, but this too, does not completely eradicate the problem.

- A simple product, made at home from liquid detergent, oil and water has, surprisingly, been shown to be very effective.

A typical bamboo plantation will contain 40 000 plants per hectare (a hectare is a square with sides 100 m long). Bamboo, with its rapid growth, needs regular feeding and considerable quantities of fertiliser are needed three times a year.

In tropical countries larger varieties of bamboo are grown for construction purposes. One variety reaches a height of 16 m in eighteen months and the bamboo is ready for harvesting after two years. One advantage of bamboo is that it is strong in both tension and compression. When used for construction the bamboo is impregnated with boric acid or borax to prevent fungal attack or infestation by insects.

Studies have been carried out to determine the feasibility of using bamboo, in place of steel, to reinforce concrete. Unfortunately the bamboo tends to absorb water from the concrete mixture, causing the bamboo to swell. When it dries out, it then shrinks causing poor adhesion and breakage of the concrete.

In some places bamboo grows excessively quickly, spreading over large areas and eradication has proved difficult. Grazing cattle are sometimes effective, as they chew the growing shoots and exhaust the plant so that it dies.

Another solution is to use a herbicide such as sodium trifluoroethanoate. Unfortunately this sterilises the soil so that nothing can be grown on it for at least three months.

Bamboo was first used by the ancient Chinese and has a very long history. It continues to be a very important commodity. Taiwan, uses 80 000 tonnes of bamboo annually.

BLANK PAGE

BLANK PAGE